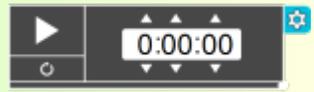
Current and charge	**1 - Current**

Learning objectives	**MUST (C)**	Recall the definition, symbol and unit for electric current
	SHOULD (B)	Explain the meaning of **charge** and **elementary charge**
	COULD (A/A*)	Explain how the Millikan oil drop experiment identified the charge of an electron

STARTER: You can't see the ends of an insulated wire - there might be a current running through it, or there might not. How might you be able to tell?

EXTENSION: Can you give an explanation of charge? What does it do, and how do we define it?



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Current & charge	1 - Charge
MUST (C)	Recall the definition, symbol and unit for electric current

Defining current

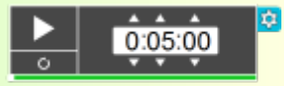
Electric current is defined as the rate of flow of charge. We write it as:

$$I = \frac{\Delta Q}{\Delta t}$$

I = current (amperes)

ΔQ = charge transferred (coulombs)

Δt = time (seconds)



If the current in a circuit is 3A, what does this tell you about the circuit?

Every second, 3C of charge passes **every point** in the circuit

1. A total of 45,000C passes through a heater in an hour. What is the current?
2. A kettle runs on 8.7A. If it takes 90 seconds to boil enough water for a well-deserved mug of coffee for a hard-working teacher, how many coulombs of charge are required?

Extension: what's the relationship between the units A and C?

1. A total of 45,000C passes through a heater in an hour. What is the current?

45,000C for ΔQ and 3600 for Δt, recalling that the SI unit for time is seconds. I = 45,000/3600, or **12.5A**.

2. A kettle runs on 8.7A. If it takes 90 seconds to boil enough water for a well-deserved mug of coffee for a hard-working teacher, how many coulombs of charge are required?

$$\Delta Q = I\Delta t$$

8.7A * 90 = **783 C**

Extension: what's the relationship between the units A and C?

1 C = 1 A s

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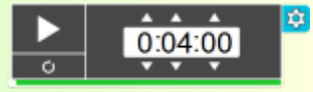
Current & Charge	**1 - Current**
SHOULD (B)	Explain the meaning of **charge** and **elementary charge**

We studied charge at GCSE: what actually ***is*** charge?

How can you tell if an object is charged?



What is charge?

Charge is a physical property of matter. A charged object will experience a force in an electromagnetic field. An object with no charge is referred to as 'neutral'.

We can recall from GCSE that like charges repel, and unlike charges attract.

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Electrically charged particles are 'charge carriers'. Look at the table to the right:

- what relationships can you see?
- what implications do these have for the charge of an atom/ion?

Table 1 *Charges*

Charge carrier	Charge / C
proton	1.60×10^{-19}
electron	-1.60×10^{-19}
$copper^{2+}$ ion	3.20×10^{-19}
$sodium^{+}$ ion	1.60×10^{-19}
$chloride^{-}$ ion	-1.60×10^{-19}

How many electrons are needed for a cup of coffee? (Use our earlier calculated value)

$$Number\ of\ electrons\ required = \frac{783\text{C}}{1.6 \times 10^{-19}\text{C}} = 4.89 \times 10^{21}$$

Extension: How many electrons in one coulomb?

$$1\text{C}/1.60 \times 10^{-19} = 6.25 \times 10^{18}$$

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Current & Charge	**1 - Charge**
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Charge

The charge of an electron is called the elementary charge, *e*. Why must the charge on any object be a multiple of *e*?

Charge is *quantised* - it can only take certain values. The smallest value is the elementary charge, and so the charge of every object must be a multiple of the elementary charge.

Net charge

Net charge $Q = \pm ne$

Q is the net charge, n is the number of electrons, and e is the charge on the electron. Why is there a ± sign?

Because electrons can be added or removed.

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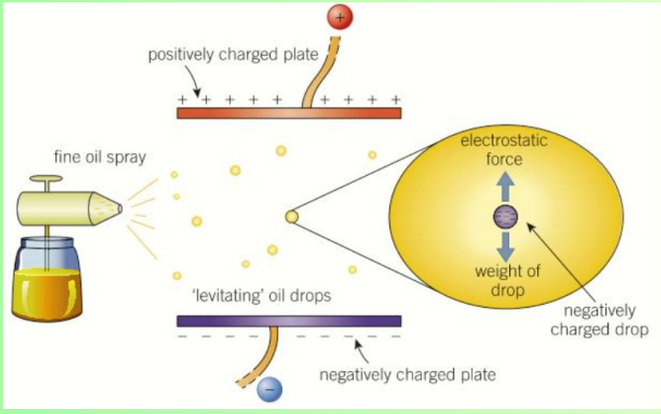
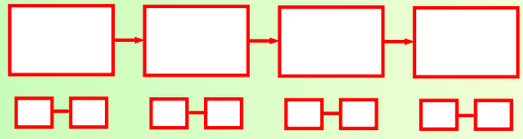
Current & Charge	**1 - Charge**
COULD (A/A*)	Explain how the Millikan oil drop experiment identified the charge of an electron

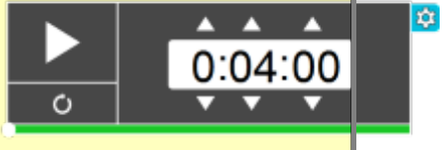


How did Millikan use this apparatus to determine the charge of the electron?



https://ophysics.com/em2.html

1. He found the mass of the drop (from its terminal velocity)
2. Weight = mg: he adjusted the electric field until the drop did not move.
3. At this point, mg = the electrostatic force on the drop, and he could calculate the charge.



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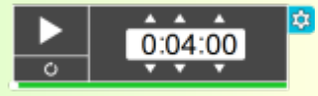
PLENARY We've learned that the elementary charge is a negative number. Is this counter-intuitive? How did this happen?

Electric vocabulary



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